Ultra-Low SAR MR Imaging of the Brain at 1.5 Tesla

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INTRODUCTION

Several implanted medical devices (e.g. deep brain stimulators, pacemakers etc.) present routine MRI contraindications due to local tissue heating or potential device malfunction from induced RF absorption. For some of these implants device manufacturers have introduced ad hoc guidelines to increase MR safety. Since these constraints reduce MRI quality or implant choices or may totally exclude MRI scans, we explored the limits to which SAR can be lowered using a modified 3D FSE sequence while preserving the image quality. Using optimized low refocusing flip angle trains, isotropic high resolution 3D T_2 and FLAIR acquisitions with quality comparable to clinical MRI were achieved for brain imaging with SAR 100x lower than standard clinical scans. This approach may offer considerable flexibility and MRI safety for imaging patients with various medical implants. FSE T_2 and FLAIR imaging typically require numerous 180° RF pulses causing a significant amount of SAR. It has been recognized that reduction of the refocusing flip angles in FSE can reduce SAR (1) without compromising contrast or sensitivity (2). The manipulation of refocusing flip angles has been of recent interest (3). This work follows a similar approach to reduce SAR levels by 2 orders of magnitude while maintains clinical image quality. This minimizes the risk involved with high SAR and may offer MRI options to currently contraindicated patients with implants and pacemakers.

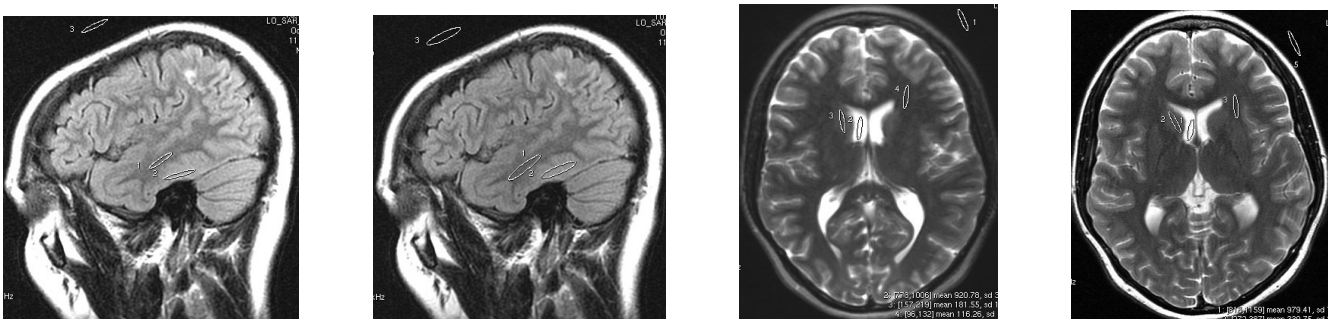
METHODS

Using a 3D-FRFSE research sequence (3), we combined the pseudo-steady state method (1-2) to optimize very long echo train FSE refocusing pulses including FA, stretched RF pulses and parallel imaging to achieve ultra-low SAR levels as well as isotropic, high resolution 3D acquisition of brain in all 3 planes. The modifications were done on fluid phantoms and on 3 healthy volunteers (age 22-50) under IRB approval. Refocusing FAs in each echo train were: the first (120^0), minimum (35^0), center (45^0), and last (60^0) with pulse widths stretched to 1.03 ms or more. Low SAR range of scan parameters were: # acquisition slices = 120-160, slice thickness = 1-2.2 mm, FOV= 220 – 250 mm, matrix = 224^2 or 256^2, TR = 6-12 s, TE_{eff} = 80-140 ms, ETL= 70-180, BW = ±31-83 kHz, scan time= 7-11 min. 32-slice Clinical 2D FLAIR and 2D FSE T_2 sequences were run for quality comparison. SNR and CNR values were computed in gray and white matter and in ventricular CSF (Table 1).

RESULTS

Table 1: SNR and CNR comparisons between 3D ultra low-SAR FLAIR and FSE T_2 method with those from clinical 2D FLAIR and 2D FSE T_2.

SEQUENCE UTILIZED	SNR & CNR (Lateral Temporal Lobe)					SNR & CNR (Anterior Temporal Lobe)			Average SAR
	GM	WM	CSF	CNR(gm,wm)	CNR(gm,csf)	GM	WM	CNR (gm,wm)	(W/kg)
3D Low-SAR FR-FSE FLAIR	87	51	15	36	72	101	28	73	0.02-0.03
Clinical 2D FLAIR (32 slice)	47	32	4	15	43	50	28	22	1.00
3D Low-SAR FRFSE T_2	96	61	360-485	35	320-425				0.01-0.02
Clinical 2D FRFSE T_2 (32 slice)	36	26	107	10	71				2.00



A. **B.** **C.** **D.**

Fig.1 (A) low-SAR 3D FLAIR section with 5 slices averaged to match (B) 5mm thick 2D Clinical FLAIR section. Also shown is (C) 3D axial reformat with 5 mm average from 1 mm low-SAR 3D T_2 acquisition and (D) 5 mm thick 2D Clinical T_2 image. ROIs in GM, WM and CSF are used to compute SNR and CNR (Table 1).

CONCLUSIONS

The goal of significantly low SAR FLAIR and T_2 MRI can be achieved by appropriate modulation of the refocusing flip angles and their pulse widths in 3D-FSE. We have demonstrated approximately 2 orders of magnitude SAR reduction with isotropic, 1-mm resolution for brain imaging at 1.5T compared to clinical FSE sequences. This approach may provide safe MRI options for patients with active implants or perhaps pacemakers when high SAR in routine MRI is the primary contraindication.

REFERENCES

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